AD NUMBER

AD039818

NEW LIMITATION CHANGE

TO

Approved for public release, distribution unlimited

FROM

Distribution authorized to U.S. Gov't. agencies and their contractors; Operational and Administrative Use; 7 Apr 1952. Other requests shall be referred to the Department of the Air Force, Attn: Public Affairs Office, Washington, DC, 20330.

AUTHORITY

AFMC ltr, 19 Feb 2002

Armed Services Technical Information Agency

Because of our limited supply, you are requested to return this copy WHEN IT HAS SERVED YOUR PURPOSE so that it may be made available to other requesters. Your cooperation will be appreciated.

AD 39818

~~RESTRICTED~~

J-47 JET ENGINE COMPRESSOR FAILURES

1 June 1950 - 31 December 1951

Office of The Inspector General, USAF

Norton Air Force Base, California

(I-8-52)

7 April 1952

~~RESTRICTED~~

A STUDY

By the

Directorate of Flight Safety Research

J-47 JET ENGINE COMPRESSOR FAILURES

For the Period

1 June 1950 through 31 December 1951

SUMMARY

This study was initiated by the Director, Flight Safety Research to investigate a specific type of J-47-GE engine compressor failure; namely, fatigue failure of compressor rotor and stator blades. This type of failure usually causes complete compressor disintegration. Statistics from engine Disassembly Inspection Reports (DIR's) and Aircraft Accident Reports were used in the preparation of this study.

Ten F-86 accidents and one B-45 accident were caused by J-47 engine compressor failures in 1951. It is believed that these accidents were caused either by fatigue failure of compressor rotor blades, or by entry of foreign material. The most likely cause for J-47 engine compressor disintegrations (excluding foreign material damage) is fatigue failure of rotor blades. There is no "fix" which will preclude this type of failure. However, a decrease in compressor failures should result from changes in compressor design and improved minor overhaul procedures. Recommendations are made which, if implemented, would accomplish two things: (1) provide a positive correlation between compressor operating hours and compressor failures; (2) minimize compressor failure accidents which may be occurring due to inadequate field inspection of rotor blades.

~~RESTRICTED~~

CONTENTS

~~RESTRICTED~~

RESTRICTED

SECTION 1

RESTRICTED

J-47 JET ENGINE COMPRESSOR FAILURES

I. PURPOSE

1. This study was originated by the Director, Flight Safety Research, to investigate J-47 jet engine compressor blade fatigue failures.

II. CONCLUSIONS

2. IT IS CONCLUDED THAT:

a. The most likely cause for J-47 engine compressor disintegration (excluding entry of foreign material) is failure of rotor blades due to metal fatigue (see pars 5 and 8).

b. J-47-GE engine compressor rotor failures cannot be correlated with rotor total operating hours (see par 9).

c. Minor overhaul procedures for jet engines with axial flow compressors should specify a visual inspection of compressor rotor and stator blades (see par 10).

d. Future axial flow compressor design should provide for access plates in the compressor case which would permit periodic inspection of rotor blades by field organizations (see par 11).

III. RECOMMENDATIONS

3. IT IS RECOMMENDED THAT THE COMMANDING GENERAL, AIR MATERIEL COMMAND:

a. Issue instructions to J-47-GE engine overhaul facilities to insure that compressor rotor operating time is recorded on the Form 60B (Engine Historical Record) (see par 9).

b. Revise forthcoming J-47-GE minor overhaul procedures to specify removal of the compressor case and inspection of all stator and rotor blades (see par 10).

4. IT IS RECOMMENDED THAT THE COMMANDING GENERAL, AIR RESEARCH AND DEVELOPMENT COMMAND:

a. Study the problems involved in axial flow compressor case design for the purpose of providing access plates in future compressors which would permit periodic inspection of compressor rotor blades (see par 11).

IV. FACTUAL DATA

5. A total of 1060 J-47 engine Disassembly Inspection Reports (DIR's) were reviewed to determine how many compressor rotor and/or stator blade failures were reported by Disassembly Reports from 1 June 1950 through 31 October 1951. Failures were selected which were thought to have been caused by metal fatigue of the blades. This excludes all compressor failures known to be caused by entry of foreign material. Fatigue failure of rotor blades is suspected in cases of compressor failure which result in severe damage to several stages. A compressor rotor blade may fail in three ways: impact, rupture and fatigue. Impact is not considered in this study, since it requires entry of a foreign object. Rupture would be preceded by yielding of the metal due to excessive stresses. This does not seem feasible since compressor rotor blade stresses lie well within the mechanical property limits of the blade material. Fatigue failures remain to be investigated. Seven suspected rotor blade fatigue failures were reported, six on engines which had been previously overhauled and one on a new engine (see Tab A). Only one of the previously overhauled engines had over 200 hours total operating time. The engine hours (since new or last overhaul) at time of failure varied from 13 to 104 hours with an average of 46.6 hours. Seven hundred and seventy DIR's on new engines were reviewed against 290 DIR's on previously overhauled engines. Furthermore, throughout 1951 there were three times as many new engines in service as there were previously overhauled engines. It is apparent that overhauled engines are more susceptible to compressor failure.

6. In addition, a survey was made of all aircraft accidents in 1951 which were caused by J-47 engine compressor failures. This survey disclosed that compressor failures caused ten F-86 accidents and one B-45 accident (see Tab B). Eight F-86 aircraft were destroyed and one pilot was killed. The exact cause of the compressor failures is unknown in every case. Accident-wise, the compressor failure rate per 100,000 engine hours increased from 4.3 in the first seven months of 1951 to 6.4 in the last five months of 1951. This represents an increase of 49% (see Tab C). The engine hours (since new or overhaul) at time of failure varied from 13 to 64 hours, with an average of 36.2 hours. The status of the engines involved in the accidents was as follows: seven engines had been previously overhauled, three engines were new and the status of one is unknown.

~~STATISTICAL~~ SUMMARY

Engine Status	Number of DIR's	Number of Compressor Failures	Number of Accidents	Average Total Engine Hours
New Engine	770	1	3	39
Previously Overhauled Engines	290	6	7	120

*Throughout 1951 there were three times as many new engines in service as previously overhauled engines.

7. The statistics in paragraph 6 indicate that engine overhaul procedures could have been a factor causing the extremely high proportion of overhauled engine compressor failures as compared with new engine failures. All the engines involved in this study were overhauled at Oklahoma City Air Materiel Area prior to June 1951. Since that time the procedures used on the overhaul line at Oklahoma City Air Materiel Area have been extensively revised as a result of inspection by teams from the Office of the Deputy Inspector General, Air Materiel Command, Wright Air Development Center, and engine manufacturers. Several irregularities in the methods of overhauling J-47 engine compressors were noted. The compressor section was being assembled in the horizontal position rather than in the vertical position. This aggravated an already critical problem of misalignment. Damaged spacer ring pins were being removed by striking them with a hammer instead of pulling them with a force applied parallel to the axis of the hole. Excessive first stage clearances were being corrected by striking the first stage wheel with a hammer rather than by application of pressure in conjunction with a backing ring to distribute the pressure over the entire wheel rim area. Air Materiel Command instructions pertinent to the allowable compressor rotor and stator blade looseness have been amended. All of these revised procedures were placed in effect at Oklahoma City Air Materiel Area by authority contained in an Air Materiel Command teletype, MCMMTP11-8-61-M, dated 15 August 1951 from the Maintenance Division. J-47 engine overhaul techniques at Oklahoma City Air Materiel Area have improved considerably since August 1951 (see Tab D).

8. The exact cause of compressor malfunction is unknown in the 11 compressor failure accidents which occurred in 1951. It is very difficult to pinpoint the initial failure of a jet engine compressor. The disintegration type of failure generally associated with axial flow compressors may be caused by foreign object damage, fatigue

failure of stator or rotor blades, rotor blade-to-case rub, rotor wheel rim failures or main bearing failures. The passage of foreign material through the compressor will sometimes nick or dent blades in the first few stages. If this is the case, then the accident investigator may be reasonably certain that foreign objects caused the compressor to disintegrate. However, foreign objects have been known to pass completely through several stages without leaving a trace, and then wipe out the last stages where blade clearances are much smaller. A main bearing failure will often induce compressor disintegration. Lacking evidence to the contrary, the overhaul depot or the accident investigator is forced to assume that a stator or rotor blade failure occurred due to metal fatigue. The truth is that not one case of blade fatigue failure has been proven in cases where several rotor stages are damaged, the reason being that some blades are always missing and the blade roots mutilated, thus precluding a determination of blade fatigue. It is likely that the first blade to fail will be among those missing. A General Electric engineer reports that five compressor failures have been definitely attributed to rotor blade fatigue failure. In each of these five instances only one (or a few) blades were damaged; hence, the fracture faces of the blade were not mutilated and fatigue rings were evident in the metal. It is generally conceded that the rotor blades are far more subject to fatigue failures than the stator blades. Rotor blades in the last three stages are dovetailed into steel wheels, whereas blades in stages one through nine are dovetailed into aluminum wheels. The energy required to excite destructive vibration in rotor blades held in steel dovetails is much less than that required for destruction of blades held in aluminum. Tests have proven that stator blades will become loose rather than undergo fatigue failure. Hence, rotor blades in the last three stages are more likely to fail due to metal fatigue. Overspeed operation and long usage may cause rotor blade elongation or compressor case distortion. This could cause blade-to-case rub and blade failure. There is no practical method of detecting incipient metal fatigue of a rotor or stator blade at time of overhaul if the fatigue originates from a stress concentration or intergranular changes. The magnaflux inspection of the blades at time of overhaul will not disclose an impending failure because by the time the fatigue crack appears on the surface the blade will have failed. General Electric is introducing three compressor design changes in an effort to minimize blade fatigue failure, blade looseness and blade rub. These are: replacement of magnesium compressor cases with 24 ST aluminum alloy cases; use of 24 ST aluminum alloy stator blade rings, and a reduction in compressor blade hardness from Rockwell C32 - C38, to Rockwell C20 - C28. In addition, a new curvic coupling compressor rotor is being developed. This rotor represents a deviation from present design in that the rotor wheels are interlocked by means of serrations on the wheel disks. Retaining bolts are passed through all rotor wheels and insure positive alignment. This type of construction will facilitate compressor overhaul because present rotor wheels must be shrunk-fit on a shaft.

9. Another factor which was investigated is that of correlating compressor failures with engine total operating time. The statistics contained in Tabs A and B show no connection between failures and length of service. However, since compressor rotors are pooled whenever parts shortages delay the overhaul of the rotor, the total rotor operating hours may or may not be the same as the total engine operating hours. Furthermore, 30 to 35 per cent of all rotors received for overhaul are disassembled to replace damaged blades, correct excessive stage-to-spacer gap, etc. At the present time, there is no way to correlate compressor failures with total compressor operating hours. Records to provide such a correlation are essential. Particularly on a unit like a compressor rotor whose failures have cost the United States Air Force over $1,500,000 in 1951. Compressor rotor operating time could be recorded on the Form 60B (Engine Historical Record).

10. During the survey of Disassembly Reports, eight instances were noted where engines had been returned to the depot for excessive vibration and/or oil leaks; upon disassembly they were found to have several compressor blades nicked or bent beyond maximum allowances. Each one of these engines represented a potential aircraft accident. Field maintenance personnel are not permitted to remove the compressor case. They can examine only the entrance guide vanes and one or two stages of the compressor for evidence of blade damage. This is not a sufficient inspection. Serious damage may be incurred by blades in stages three through 12 without any visual evidence on blades in stages one and two. General Electric Company has completed a procedure to be followed in accomplishing minor overhaul of J-47 engines in the field. Removal of the compressor case is not authorized in this procedure. It is believed that consideration should be given to a revision of the proposed minor overhaul instructions which would require removal of the compressor case and inspection of all stator and rotor blades.

11. Axial flow compressors have inherent characteristics of high centrifugal and aerodynamic forces, and high temperatures (400°F) which combine to render them subject to a disintegrating type of failure. This is true today and will continue to be true in the foreseeable future. One defense against this type of failure is periodic inspection of the rotors for damage due to foreign objects. This is difficult to accomplish with present compressor case design. Thorough periodic rotor blade inspection would be possible if access plates were provided in future compressor case design.

12. In this study an attempt has been made to accentuate the well-known problem of axial flow compressor failures through the medium of Flight Safety Research statistics in conjunction with jet engine Disassembly Inspection Reports. It is felt that if the recommendations made are considered feasible and are acted upon, the USAF compressor failure rate will be reduced.

V. TABULAR MATERIAL

Tab A	Table I, Disassembly Inspection Report Statistics
Tab B	Table II, Aircraft Accident Statistics
Tab C	Table III, Compressor Failure Rates
Tab D	Extract, Oklahoma City Air Materiel Area Inspection

RESTRICTED

SECTION 2

RESTRICTED

TABLE I (TAB A)

*J-47 Engine Compressor Rotor Blade Failures as Compiled from a Review of 1060 DIR's

Covering a Period from 1 June 1950 through 31 October 1951

Engine Ser. No.	Series Engine	Hours @ Overhaul	Hours Since Overhaul	Total Hours	Depot	Date of Overhaul	Aircraft Model	Date of Failures
041994	-13	47	71	118	OCAMA	5-15-50	RB-45C	June 1951
041466	-13	47	22	69	OCAMA	4-24-50	F-86A	Dec 1950
041558	-13	17	50	67	OCAMA	3-24-50	F-86	June 1950
041659	-7	New	New	33	New		F-86	June 1950
041903	-13	39	13	52	OCAMA	3- 7-50	B-45	June 1951
042258	-13	145	104	249	OCAMA	4- 4-51	F-86	July 1951
042166	-13	123	33	156	OCAMA	10-2-51	RB-45C	July 1951

*Foreign material damage excluded.

RESTRICTED

TABLE II (TAB B)

F-86 and B-45 Aircraft Accidents Caused by J-47 Engine Compressor Failures

from 1 January 1951 through 31 December 1951

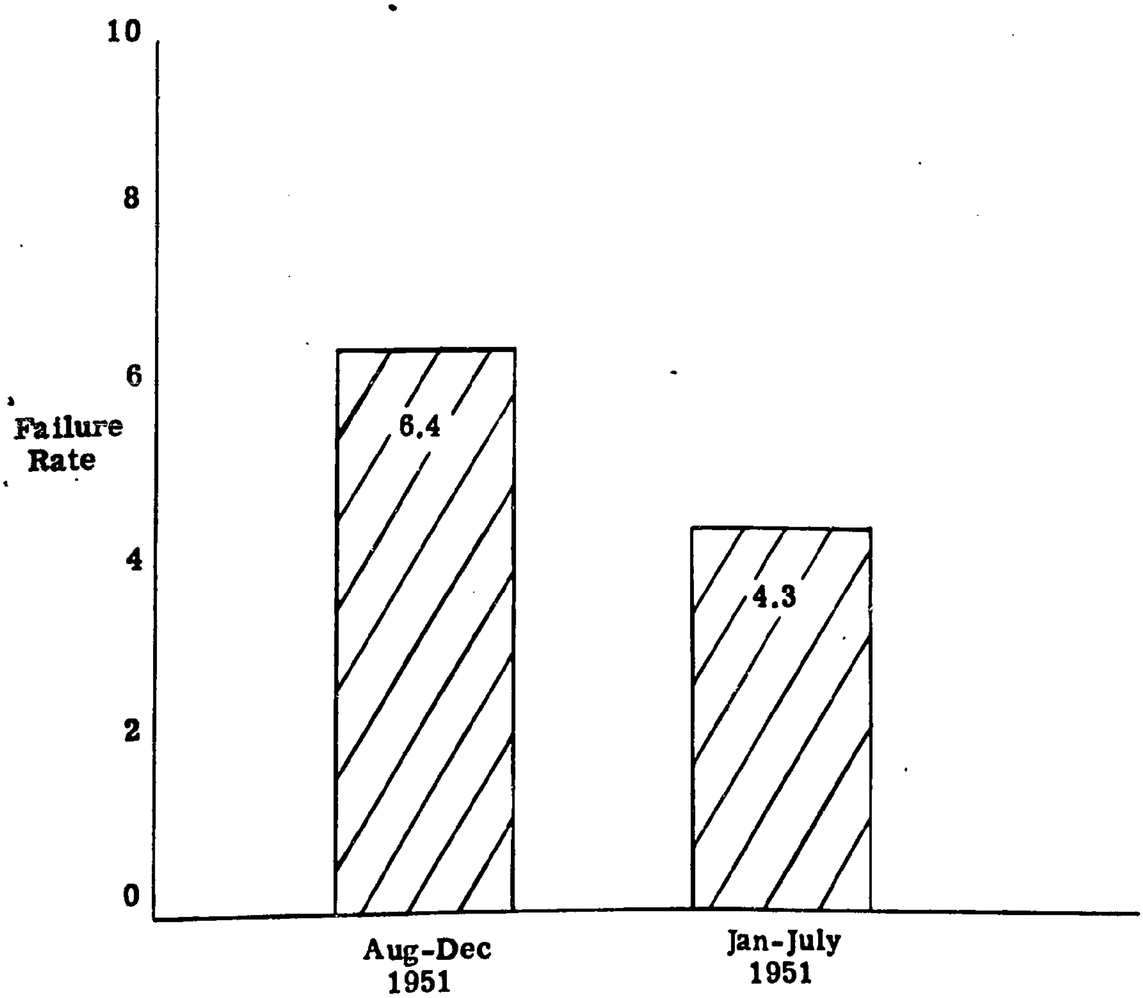
Accident Number	Engine Ser. No.	Time Since Overhaul	Total Hours	Injury	Damage to Acft.	Cost	Engine Series	Type Acft.
51-1-23-2	046-551	New	23:15	None	Destroyed	$ 185,000	-13	F-86
51-1-31-6	041-484	63:50	82:50	Fatal	Destroyed	185,000	-13	F-86
51-4-1-1	046-590	New	39:25	None	Destroyed	185,000	-13	F-86
51-7-7-1	042-166	33:05	156:05	None	Minor	92,000	-13	B-45
51-7-29-2	041-363	30:35	Unknown	Minor	Destroyed	185,000	-7A	F-86
51-8-22-8	041-237	12:55	39:50	None	Destroyed	257,000	-7	F-86
51-9-14-1	042-148	20:50	258:50	None	Substantial	50,000	-13	F-86
51-9-20-3	041-373	19:05	29:05	None	Destroyed	257,000	-7A	F-86
51-10-7-4	041-716	New	61:20	Minor	Destroyed	185,000	-13	F-86
51-10-22-2	042-047	58:30	166:30	None	Substantial	12,000	-13	F-86
51-11-9-5	Unknown	Unknown	Unknown	Major	Destroyed	185,000	Unknown	F-86

RESTRICTED

TABLE III

1951 COMPRESSOR ACCIDENT RATES PER 100,000 ENGINE HOURS

JAN-JULY VS AUG-DEC



TAB C

TAB D

INCLOSURE NO. 6

Report of Formal Technical Inspection of the Directorate of Maintenance, OCAMA, conducted by representatives of The Inspector General, USAF, Norton Air Force Base, California, 6 - 21 January 1952.

ENGINE REPAIR SECTION (JET)

PART I

Action taken on Special Inspection, Jet Overhaul Program, OCAMA, conducted by representatives of the Deputy Inspector General, Norton Air Force Base, California, 19 May 1951.

1. The inspection branch of the Engine Repair Section (Jet) had been increased from five to eleven per cent of the production personnel in order to adequately perform the mission. Production personnel, authorized to do inspection work, had been reduced to a minimum (12), and were relegated to segregating and checking non-critical bits and pieces and filling in nomenclature on inspection tags. An inspection school had been organized and all inspection personnel were attending or were scheduled to attend.

2. Information dissemination, work station job sheets, proper parts baskets, and better handling procedures had been developed and were in force. Proper tools, visual aids and tool boards were in evidence and in use. There had been a complete control established over the issue of small parts for engine buildup (see Tab A to this inclosure).

3. The OCAMA Engine Repair Section (Jet) personnel and others connected with its operation had accomplished an outstanding job in improving the jet overhaul function.

- * * * * * * * * * -

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AIR FORCE MATERIEL COMMAND
WRIGHT-PATTERSON AIR FORCE BASE OHIO

FEB 1 9 2002

MEMORANDUM FOR DTIC/OCQ (ZENA ROGERS)
8725 JOHN J. KINGMAN ROAD, SUITE 0944
FORT BELVOIR VA 22060-6218

FROM: AFMC CSO/SCOC
4225 Logistics Avenue, Room S132
Wright-Patterson AFB OH 45433-5714

SUBJECT: Technical Reports Cleared for Public Release

References: (a) HQ AFMC/PAX Memo, 26 Nov 01, Security and Policy Review, AFMC 01-242 (Atch 1)

(b) HQ AFMC/PAX Memo, 19 Dec 01, Security and Policy Review, AFMC 01-275 (Atch 2)

(c) HQ AFMC/PAX Memo, 17 Jan 02, Security and Policy Review, AFMC 02-005 (Atch 3)

1. Technical reports submitted in the attached references listed above are cleared for public release in accordance with AFI 35-101, 26 Jul 01, *Public Affairs Policies and Procedures*, Chapter 15 (Cases AFMC 01-242, AFMC 01-275, & AFMC 02-005).

2. Please direct further questions to Lezora U. Nobles, AFMC CSO/SCOC, DSN 787-8583.

Lezora U. Nobles

LEZORA U. NOBLES
AFMC STINFO Assistant
Directorate of Communications and Information

Attachments:
1. HQ AFMC/PAX Memo, 26 Nov 01
2. HQ AFMC/PAX Memo, 19 Dec 01
3. HQ AFMC/PAX Memo, 17 Jan 02

cc:
HQ AFMC/HO (Dr. William Elliott)

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AIR FORCE MATERIEL COMMAND
WRIGHT-PATTERSON AIR FORCE BASE OHIO

DEC 19 2001

MEMORANDUM FOR HQ AFMC/HO

FROM: HQ AFMC/PAX

SUBJECT: Security and Policy Review, AFMC 01-275

1. The reports listed in your attached letter were submitted for security and policy review IAW AFI 35-101, Chapter 15. They have been cleared for public release.

2. If you have any questions, please call me at 77828. Thanks.

JAMES A. MORROW
Security and Policy Review
Office of Public Affairs

Attachment:
Your Ltr 18 November 2001

18 December 2001

MEMORANDUM FOR: HQ AFMC/PAX
Attn: Jim Morrow

FROM: HQ AFMC/HO

SUBJECT: Releasability Reviews

1. Please conduct public releasability reviews for the following attached Defense Technical Information Center (DTIC) reports:

   a. *Emergency Fuel Selector Valve Test on the J47-GE-27 Engine as Installed on F-86F Aircraft*, January 1955; DTIC No. AD- 056 013.

   b. *Phase II Performance and Serviceability Tests of the F-86F Airplane USAF No. 51-13506 with Pre-Turbine Modifications*, June 1954; DTIC No. AD- 037 710.

   c. *J-47 Jet Engine Compressor Failures*, 7 April 1952; DTIC No. AD- 039 818.

   d. *Evaluation of Aircraft Armament Installation (F-86F with 206 RK Guns) Project Gun-Val*, February 1955; DTIC No. AD- 056 763.

   e. *A Study of Serviced-Imposed Maneuvers of Four Jet Fighter Airplanes in Relation to Their Handling Qualities and Calculated Dynamic Characteristics*, 15 August 1955; DTIC No. AD- 068 899.

   f. *Fuel Booster Pump*, 6 February 1953; DTIC No. AD- 007 226.

   g. *Flight Investigation of Stability Fix for F-86F Aircraft*, 8 September 1953; DTIC No. AD- 032 259.

   h. *Investigation of Engine Operational Deficiencies in the F-86F Airplane*, June 1953; DTIC No. AD- 015 749.

   i. *Operational Suitability Test of the T-160 20mm Gun Installation in F-86F-2 Aircraft*, 29 April 1954; DTIC No. AD- 031 528.

   j. *Engineering Evaluation of Type T 160 Gun and Installation in F 86 Aircraft*, September 1953; DTIC No. AD- 019 809.

AFMC 01-2 7 3

k. *Airplane and Engine Responses to Abrupt Throttle Steps as Determined from Flight Tests of Eight Jet-Propelled Airplanes*, September 1959; DTIC No. AD-225 780.

l. *Improved F-86F: Combat Developed*, 28 January 1953; DTIC No. AD- 003 153.

m. *Flight Test Progress Report No. 19 for Week Ending February 27, 1953 for Model F-86F Airplane NAA Model No. NA-191*, 5 March 1953; DTIC No. AD-006 806.

2. These attachments have been requested by Dr. Kenneth P. Werrell, a private researcher.

3. The AFMC/HO point of contact for these reviews is Dr. William Elliott, who may be reached at extension 77476.

John D. Weber
JOHN D. WEBER
Command Historian

13 Attachments:
a. DTIC No. AD- 056 013
b. DTIC No. AD- 037 710
c. DTIC No. AD- 039 818
d. DTIC No. AD- 056 763
e. DTIC No. AD- 068 899
f. DTIC No. AD- 007 226
g. DTIC No. AD- 032 259
h. DTIC No. AD- 015 749
i. DTIC No. AD- 031 528
j. DTIC No. AD- 019 809
k. DTIC No. AD- 225 780
l. DTIC No. AD- 003 153
m. DTIC No. AD- 006 806